Perioperative Blood Pressure Control in Hypertensive and Normotensive Patients Undergoing Off-pump Coronary Artery Bypass Grafting: Prospective Study of Current Anesthesia Practice

Stjepan Barišin[1], Kata Šakić[2], Tatjana Goranović[1], Ana Barišin[3], Zdenko Sonicki[4]

[1]Department of Anesthesiology, Resuscitation, and Intensive Care, Dubrava University Hospital, Zagreb, Croatia
[2]Department of Anesthesiology, Resuscitation, and Intensive Care, Zagreb University Hospital Center, Zagreb, Croatia
[3]Department of Medicine, Merkur University Hospital, Zagreb, Croatia
[4]Andrija Štampar School of Public Health, Zagreb University School of Medicine, Zagreb, Croatia

> **Correspondence to:**

Stjepan Barišin
Department of Anesthesiology, Resuscitation and Intensive Care
Department of Cardiac Anesthesia and Intensive Care
Dubrava University Hospital
Gojka Šuška Av. 6
10000 Zagreb, Croatia
stjepan.barisin@zg.htnet.hr

> **Received:** December 17, 2006
> **Accepted:** March 1, 2007

> **Croat Med J. 2007;48:341-7**

Aim To analyze blood pressure changes during intra- and immediate postoperative period in patients undergoing off-pump coronary artery bypass grafting.

Methods The study included 355 consecutive patients undergoing off-pump coronary artery bypass grafting between January 5, 2004 and December 30, 2005. Out of these patients, 325 were allocated into groups with preoperative history of hypertension (n = 115) and without preoperative history of hypertension (n = 210). Systolic, diastolic, and mean arterial blood pressure was measured at the following four time points: on the day before surgery, before anesthesia induction, after the last graft, and on entry to intensive care unit.

Results Mean arterial pressure was significantly higher in patients with a history of hypertension on the day before surgery (97 vs 92 mm Hg, $P = 0.003$, Mann-Whitney test) and before anesthesia induction (107 vs 98 mm Hg; $P = 0.003$). It was higher at all measuring points (after the last graft, 79 vs 78 mm Hg; and on entry to intensive care unit, 88 vs 86 mm Hg), but this difference was neither statistically nor clinically significant. The study showed that mean arterial pressure followed similar dynamics over time in both patient groups ($P<0.001$ both), with no significant time-dependent between-group differences.

Conclusion Current anesthesia techniques that include deep opioid analgesia in combination with vasodilators provide a satisfactory control of intraoperative hypertension. Management of blood pressure changes during intra- and immediate postoperative period in off-pump coronary artery bypass grafting patients with preoperative hypertension was no more difficult than in patients without preoperative hypertension.

Monitoring of hemodynamic stability, especially blood pressure and heart rate during perioperative period, is an important consideration (1). During conventional open heart surgery, hypertension can occur at almost any time, ie before, during, or after surgery, and is most commonly mediated by an increase in sympathetic tone.

Off-pump coronary artery bypass grafting is a procedure that may achieve better in-hospital outcome, including shorter length of stay (2,3). Hypertension associated with off-pump coronary artery bypass grafting is typically not a result of dramatic increase in systemic vascular resistance (4).

The reported incidence of perioperative hypertension associated with conventional coronary artery bypass grafting (CABG) ranges from 30 to 80%, and this wide range may explain different definitions of the condition and preoperative comorbid states (5).

To the best of our knowledge, there are no studies dealing with off-pump coronary artery bypass grafting. The aim of our study was to analyze perioperative hypertensive response in patients undergoing off-pump coronary artery bypass grafting. We hypothesized that it was more difficult to control perioperative hypertension in these patients who had been preoperatively hypertensive than in those who had not.

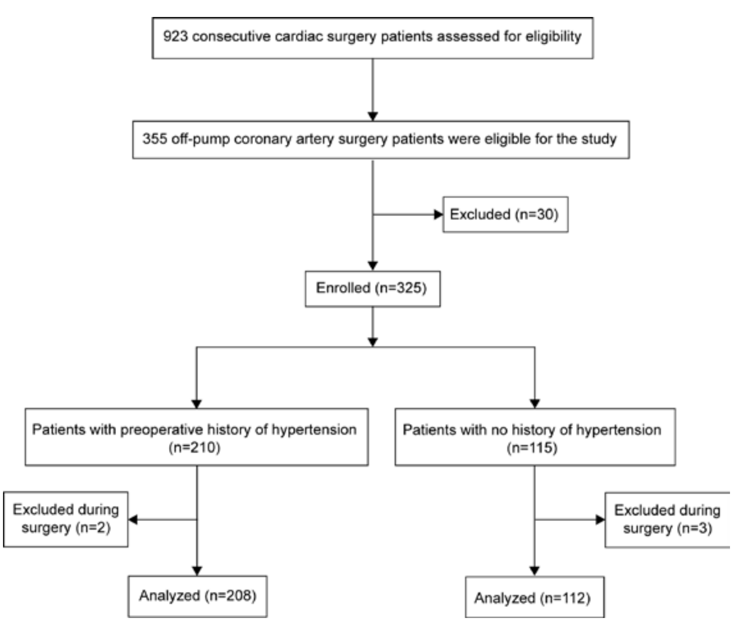

Figure 1. Flow diagram of patients throughout the study.

Patients and methods

Patients

The study took place at the Department of Anesthesiology, Resuscitation, and Intensive Care, Dubrava University Hospital, Zagreb, between January 5, 2004 and December 30, 2005. Out of 923 consecutive cardiac surgery patients admitted to the department, 535 patients were undergoing coronary artery bypass grafting. Out of them, 355 were undergoing off-pump coronary artery bypass grafting, and were eligible for the study. Of these, 30 patients met the exclusion criteria and were excluded from the study, while the rest of 325 patients were allocated either into the group with preoperative history of hypertension (n = 115) or in the group with no preoperative history of hypertension (n = 210) (Figure 1). The diagnosis of hypertension was made by a cardiologist at least 3 months before surgery. The study was performed in compliance with the Helsinki Declaration. It received institutional ethical committee approval and all patients were informed about the trial and signed the informed consent.

The inclusion clinical criteria for the study were the following: Cardiac Anesthesia Risk Evaluation (CARE) score I or II (6), angiographically verified coronary artery disease, and left ventricular ejection fraction greater or equal to 50%. There were 253 male and 67 female patients with the median (range) age of 60.5 (13.5) (Table 1). Exclusion criteria were heart disease other than coronary artery disease, atrioventricular conduction disturbances, and evidence of previous ventricular or atrial dysrhythmias requiring treatment. Patients receiving either antiarrhythmic therapy or requiring inotropic support intraoperatively were excluded from the study (n = 5).

Table 1. Patient demographics and perioperative data*

Variable	No. (%) of patients with history of hypertension (n = 208)	No. (%) of patients with no history of hypertension (n = 112)	P†
Age (years, median interquartile range)	63 (10.3)	58 (17.8)	0.015‡
Weight (kg, median interquartile range)	81.5 (13.5)	83 (20.8)	0.764‡
Height (cm, median interquartile range)	172 (10.3)	174.5 (13.3)	0.176‡
Gender (M/F)	158/50	95/17	0.138
β-adrenoreceptor antagonists	176 (84.7)	92 (82.1)	0.460
Calcium channelblockers	84 (40.0)	24 (20.8)	0.016
ACE inhibitors	126 (60.5)	52 (46.4)	0.070
Nitrates	125 (60.1)	49 (43.7)	0.057
Diuretics	62 (29.8)	13 (11.6)	0.009
Angiotensin II antagonists	23 (11.1)	6 (5.4)	0.216
Cerebrovascular event	6 (2.9)	4 (3.6)	0.743
Myocardial infarction	106 (50.9)	61 (54.4)	0.846
Diabetes mellitus	80 (38.5)	19 (16.9)	0.030
Duration of surgery (minute, median interquartile range)	180 (60.0)	155 (60.0)	0.009‡
Number of grafts	3 (1.8)	3 (1.5)	0.591‡
Duration of anesthesia (minute, median interquartile range)	240 (70.00)	220 (60.0)	0.043‡
ICU stay (days, median interquartile range)	3 (1.3)	3 (1.0)	0.133‡
Hospital stay (days, median interquartile range)	2 (4.0)	12 (4.0)	0.959‡
Nitrates during surgery	189 (90.8)	88 (78.6)	0.047
Ischemia within first eight hours in ICU	8 (3.8)	6 (5.4)	0.694

*Abbreviations: ACE – angiotensin converting enzyme inhibitors; ICU – intensive care unit.
†Comparison between groups, Fisher exact test.
‡Comparison between groups, Mann-Whitney test.

Anesthesia

Patients received their cardiac medications on the morning of the surgery. Long-acting medications (calcium antagonists and angiotensin converting enzyme inhibitors) were discontinued one day before surgery. All patients were premedicated with morphine at a dose of 0.1 mg/kg IM (Morphine Merck®, Merck KgaA, Darmstadt, Germany) an hour before surgery. Anesthesia was induced with midazolam (Dormicum®, F. Hoffman-La Roche Ltd, Basel, Switzerland) 0.1 mg/kg IV, fentanyl (Fentanyl®, Janssen Pharmaceutica, Beerse, Belgium) 5-7 μg/kg IV, and pancuronium-bromide (Pavulon®, N.V. Organon, Oss, the Netherlands) 0.1 mg/kg IV. After endotracheal intubation, the lungs were mechanically ventilated using positive pressure (tidal volume 8 mL/kg, ventilatory frequency 12/min) (Cato, Dräger, Lübeck, Germany). Anesthesia was maintained with 40-60% nitrous-oxide/oxygen mixture and sevoflurane (Sevorane®, Abbott Laboratories S.A., Abbott Park, IL, USA) at the doses of 1-1.5 minimal alveolar concentration. Additional doses of pancuronium-bromide (0.1 mg/kg) and fentanyl (5 μg/kg) were administered as required to maintain neuromuscular blockade and analgesia during surgery. After induction of anesthesia, infusion of 500 mL hydroxyethylstarch 6% solution (HAES-sterile 6% in saline 0.9%, Fresenius Kabi, Bad Homburg, Germany) was administered in all patients to optimize preload.

In addition to standard anesthesia noninvasive monitoring, an arterial catheter (Arrow International, Reading, PA, USA) was inserted into the left radial artery, and central venous catheter was placed into the right internal jugular vein and monitored (Hewlett Packard Viridia CMS, Böblingen, Germany).

Study design

We recorded patients' demographic data (age, gender, weight, height), comorbidities (use of antihypertensive drugs, prior cerebrovascular events, myocardial infarction, diabetes mellitus), duration of surgery and anesthesia, number of bypass grafts performed, intensive care unit stay, coronary ischemic episode within first 8 postoperative hours, and duration of hospital stay. Furthermore, we measured blood pressure on the following time points: on the day before surgery;

before anesthesia induction; after the last bypass graft was sutured; and immediately on entry to the intensive care unit. The systolic (SBP) and diastolic blood pressure (DBP) on the day before operation was measured by sphygmomanometer. Intraoperative pressures were measured invasively by indwelling arterial catheter, as previously described. Mean arterial pressure was obtained from the measured values using the classic formula:

$$MAP = (SBP + 2 \times DBP)/3$$

All blood pressure values were expressed in mmHg. Perioperative hypertension was defined as mean arterial pressure ≥110 mm Hg (7). Intraoperative administration of nitroglycerin depended solely on the decision of the anesthesiologist in charge.

Statistical analysis

Numerical data were expressed as median and interquartile range. Qualitative data were expressed as frequencies. We used Mann-Whitney test to assess differences between the two groups and Friedman test to compare parameters measured at different time points within each group. Qualitative data were compared by Fisher exact test. Wilcoxon signed rank test was used to assess the differences in time-dependent variable pairs between the two groups.

We used Mann-Whitney test to determine the time-dependent differences between the groups in mean arterial pressure values (ΔMAP): difference between the day before surgery and before anesthesia induction; the difference between the day before surgery and after the last graft; and the difference between the day before surgery and entry to the intensive care unit. Friedman test was used to assess the dynamics of individual differences in mean arterial pressure values within each group. All statistical values were considered significant at $P<0.05$. For data analysis, the SAS System for Windows Release 8.02 software (SAS Institute Inc., Cary, NC, USA) was used.

Results

The number of male and female patients, preoperative antihypertensive medication except for calcium channel blockers and diuretics, and prevalence of history of cerebrovascular events and myocardial infarction were comparable in the two groups. There was no between-group difference in the number of grafts, incidence of ischemic episodes during the first 8 postoperative hours, and intensive care unit and hospital stay. The duration of surgery and anesthesia was longer in the hypertension group ($P=0.009$ and $P=0.043$, respectively), and so was the intraoperative use of nitrates ($P=0.047$) (Table 1).

Systolic and diastolic blood pressure recorded on the day before surgery ($P=0.001$ and $P=0.047$) and before induction ($P=0.015$ and $P=0.027$) was higher in patients with hypertension than in those without hypertension. There was no between-group difference in systolic blood pressure and diastolic blood pressure immediately after the last graft and on entry to the intensive care unit (Table 2). In patients with hypertension, higher mean arterial pressure was recorded on the day before surgery and before anesthesia induction ($P=0.003$ for both). There were significant differences in mean arterial pressure within each group ($P<0.001$ for all) (Table 3). On the day before surgery, 14 patients had mean arterial pressure ≥110 mm Hg

Table 2. Systolic (SBP) and diastolic (DBP) arterial blood pressures recorded during perioperative period*

	Median (interquartile range) in patients with		
Variable (mmHg)	history of hypertension (n = 208)	no history of hypertension (n = 112)	P†
SBP1	130 (20.00)	120 (18.75)	0.001
DBP1	80 (15.00)	75 (10.00)	0.047
SBP2	160 (41.25)	140 (32.50)	0.015
DBP2	80 (15.00)	80 (12.00)	0.027
SBP3	110 (10.00)	110 (12.50)	0.489
DBP3	60 (10.00)	60 (5.00)	0.184
SBP4	120 (20.00)	125 (25.00)	0.677
DBP4	70 (20.00)	70 (20.00)	0.373

*Abbreviations: SBP1, DBP1 – day before surgery; SBP2, DBP2 – before anesthesia induction; SBP3, DBP3 – after last bypass; SBP4, DBP4 – on entry to intensive care unit.

†Comparison between groups, Mann-Whitney test.

(11 patients with a history of hypertension and 3 patients with no history of hypertension). Before anesthesia induction, 38 patients had mean arterial pressure ≥110 mm Hg (33 patients with a history of hypertension and 5 patients with no history of hypertension). At the last bypass graft none of the patients from either group had mean arterial pressure ≥110 mm Hg. Only 4 patients had mean arterial pressure ≥110 mm Hg at entry into the intensive care unit (3 patients with a history of hypertension and 1 patient with no history of hypertension). The dynamics of mean arterial pressure showed a similar pattern over time in both groups of patients (*P*<0.001 for both), with no significant time-dependent between-group differences (Table 4).

Table 3. Mean (MAP) arterial blood pressure recorded during perioperative period*

	Median (interquartile range) in patients with		
Variable (mmHg)	history of hypertension (n = 208)	no history of hypertension (n = 112)	$P^{\dagger}$
MAP1	97 (13.33)	92 (16.25)	0.003
MAP2	107 (20.00)	98 (14.08)	0.003
MAP3	79 (7.08)	78 (7.91)	0.226
MAP4	88 (16.66)	86 (18.33)	0.400
$P^{\ddagger}$	<0.001	<0.001	

*Abbreviations: MAP1 – day before surgery; MAP2 – before anesthesia induction; MAP3 – after last bypass; MAP4 – on entry to intensive care unit.
†Comparison between groups, Mann-Whitney test.
‡Comparison within each group, Friedman test.

Table 4. Time-dependent differences of mean (ΔMAP) arterial blood pressures recorded during perioperative period*

	Median (interquartile range) in patients with		
Variable (mmHg)	history of hypertension (n = 208)	no history of hypertension (n = 112)	$P^{\dagger}$
ΔMAP1-2	-6.67 (23.33)	-3.67 (23.33)	0.311
ΔMAP1-3	16.66 (16.67)	12.50 (16.25)	0.100
ΔMAP1-4	10.00 (23.75)	6.67 (20.00)	0.347
$P^{\ddagger}$	<0.001	<0.001	

*Abbreviations: ΔMAP1-2 – difference in mean arterial pressure between day before surgery and before anesthesia induction; ΔMAP1-3 – difference in mean arterial pressure between day before surgery and after last bypass; ΔMAP1-4 – difference in mean arterial pressure between day before surgery and entry to intensive care unit.
†Comparison between groups, Mann-Whitney test.
‡Comparison within each group, Friedman test.

Discussion

Our study showed that systolic blood pressure and diastolic blood pressure recorded on the day before surgery and before anesthesia induction were higher in patients with hypertension. The management of elevated blood pressure was satisfactory in both patient groups, as systolic and diastolic blood pressures were similar immediately after the last graft and on entry to the intensive care unit. Mean arterial pressure values were higher in patients with hypertension on the day before surgery and before anesthesia induction but not immediately after the last graft and on entry to intensive care unit. Our study revealed that the dynamics of mean arterial pressure showed a similar pattern over time in both groups, with no significant time-dependent between-group differences. It should be noted that the higher mean arterial pressure before surgery had no adverse impact on the surgery outcome.

Perioperative hypertension may be related to either the underlying comorbidity or to the surgical procedure. There are many studies addressing perioperative management of hypertension (8-11). Most studies take systolic blood pressure as an indicator of postoperative hypertension with a varying the threshold level (12), whereas other studies take diastolic blood pressure (13). Alternatively, a 20% or greater increase above the preoperative level has been adopted in either systolic or diastolic blood pressure (7). We also recorded mean arterial pressure to make a direct comparison with literature data on perioperative hypertension in patients undergoing CABG. Our primary goal was to observe mean arterial pressure during intra- and immediate postoperative period in OPCABG patients with and without preoperative hypertension. The mean arterial pressure ≥110 mm Hg was set as the criterion for perioperative hypertension (7).

Patients with uncontrolled essential hypertension show marked blood pressure reactivity to perioperative stressors (14). It is believed that effective treatment of hypertension normalizes vascular reactivity (15). Patients with adequately treated hypertension are expected to exert a similar hemodynamic response to stressors as normotensive individuals. In our study, 14 patients had mean arterial pressure ≥110 mm Hg on the day before surgery. Three of these patients were proclaimed normotensive preoperatively. Further analysis showed that 38 patients had mean arterial pressure ≥110 mm Hg before anesthesia induction (33 patients with a history of hypertension and 5 patients with no history of hypertension). The possible explanation for these results may be inadequate premedication. Our patients are routinely premedicated only with morphine at a dose of 0.1 mg/kg IM one hour before transfer to the operative room. The idea of using antihypertensive agents on the morning of surgery is not novel at all, but current long-acting medications may exert significant effect on intraoperative and postoperative physiology (4). Our practice of not using antihypertensive agents, except beta-adrenergic antagonists, on the morning of surgery can be explained by the fact that there is no consensus regarding appropriate agents for most of patients.

The most common currently used method to reduce intraoperative blood pressure is to deepen anesthesia, usually in combination with vasodilators and beta-adrenergic antagonists (7). In our study, at the point of last bypass graft, none of the patients from either group had mean arterial pressure ≥110 mm Hg and only 4 patients had mean arterial pressure ≥110 mm Hg at entry into the intensive care unit (3 patients with a history of hypertension and 1 patient with no history of hypertension). These data showed that patients with a history of hypertension required more vasodilators, because the usage of nitroglycerin depended solely on the assessment of the anesthesiologist in charge. The study design prevents us from drawing further conclusions but blinding the responsible anesthesiologists to the patients' medical history regarding hypertension would be ethically unacceptable.

The study showed that our preoperative management of hypertension was far from ideal. Ideally, all hypertensive patients should be treated preoperatively (15). However, this problem is out of anesthesiologists' control. First, some patients are not compliant enough for drug therapy. Second, it should not be neglected that the policy of initiating long term treatment of hypertension in all untreated hypertensive patients may cause a considerable number of cancellations which are highly unpopular among surgeons and patients.

In conclusion, our data showed that deep anesthesia with adequate opioid analgesia in combination with vasodilators provided satisfactory control of intraoperative hypertension.

It was no more difficult to control blood pressure changes during intra- and immediate postoperative period in OPCABG patients with preoperative history of hypertension than in patients with no history of hypertension.

References

1 Hall RI. Anaesthesia for coronary artery surgery – a plea for a goal-directed approach. Can J Anaesth. 1993;40:1178-94. Medline:8281595

2 Al-Ruzzeh S, Ambler G, Asimakopoulos G, Omar RZ, Hasan R, Fabri B, et al. Off-Pump Coronary Artery Bypass (OPCAB) surgery reduces risk-stratified morbidity and mortality: a United Kingdom multi-center comparative analysis of early clinical outcome. Circulation. 2003;108 Suppl 1:II1-8. Medline:12970199

3 Barisin S, Husedzinovic I, Sonicki Z, Bradic N, Barisin A, Tonkovic D. Levosimendan in off-pump coronary artery bypass: a four-times masked controlled study. J Cardiovasc Pharmacol. 2004;44:703-8. Medline:15550791

4 St Andre AC, DelRossi A. Hemodynamic management of patients in the first 24 hours after cardiac surgery. Crit Care Med. 2005;33:2082-93. Medline:16148484

5 Leslie JB. Incidence and aetiology of perioperative hypertension. Acta Anaesthesiol Scand Suppl. 1993;99:5-9. Medline:8480508

6 Dupuis JY, Wang F, Nathan H, Lam M, Grimes S, Bourke M. The cardiac anesthesia risk evaluation score: a clinically useful predictor of mortality and morbidity after cardiac surgery. Anesthesiology. 2001;94:194-204. Medline:11176081

7 Vuylsteke A, Feneck RO, Jolin-Mellgard A, Latimer RD, Levy JH, Lynch C III, et al. Perioperative blood pressure control: a prospective survey of patient management in cardiac surgery. J Cardiothorac Vasc Anesth. 2000;14:269-73. Medline:10890479

8 Aronson S, Boisvert D, Lapp W. Isolated systolic hypertension is associated with adverse outcomes from coronary artery bypass grafting surgery. Anesth Analg. 2002;94:1079-84. Medline:11973166

9 Boersma E, Poldermans D, Bax JJ, Steyerberg EW, Thomson IR, Banga JD, et al. Predictors of cardiac events after major vascular surgery: role of clinical characteristics, dobutamine

echocardiography, and beta-blocker therapy. JAMA. 2001;285:1865-73. Medline:11308400

10 Stamler J, Stamler R, Neaton JD. Blood pressure, systolic and diastolic, and cardiovascular risks. US population data. Arch Intern Med. 1993;153:598-615. Medline:8439223

11 Howell SJ, Sear JW, Foex P. Hypertension, hypertensive heart disease and perioperative cardiac risk. Br J Anaesth. 2004;92:570-83. Medline:15013960

12 Vecht RJ, Swanson KT, Nicolaides EP, Lennox SC, Gibson DG. Comparison of intravenous nicardipine and nitroglycerin to control systemic hypertension after coronary artery bypass grafting. Am J Cardiol. 1989;64:19H-21H. Medline:2508457

13 Leslie JB, Kalayjian RW, Sirgo MA, Plachetka JR, Watkins WD. Intravenous labetalol for treatment of postoperative hypertension. Anesthesiology. 1987;67:413-6. Medline:3631615

14 Skarvan K. Perioperative hypertension: new strategies for management. Curr Opin Anaesthesiol. 1998;11:29-35. Medline:17013202

15 Foëx P, Sear JW. The surgical hypertensive patient. Continuing Education in Anaesthesia, Critical Care & Pain. 2004;4:139-43.